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ABSTRACT

The paper reviews research dealing with the process of reflective abstraction, analysis and modification of one's own behavior, in learning disabled students. A study was conducted to test the hypothesis that children with a working memory of three pieces of information, who are inclined to employ self-terminating processing strategies because of impulsivity, would benefit from training focused on analyzing properties of the response alternatives and the stem terms of figural analogy problems. The study, involving both LD and non-LD Ss (8-12 years old) found that reflective abstraction is, in part, highly related to the individual's working memory capacity and the working memory demands of a given task. Findings also suggested that when these factors are taken into account, LD children can be taught to use the process of reflective abstraction to modify their own learning behavior. (Author/CL)

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REFLECTIVE ABSTRACTION IN THE LEARNING DISABLED CHILD

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ABSTRACT

This paper will describe research focusing on the process of reflective abstraction in the learning disabled. In a study of both learning disabled and normal children it was found that this process is in part, highly related to a subject's working memory capacity and the working memory demands of a given task. It was also found that provided these factors are taken into account, learning disabled children can be taught to use the process of reflective abstraction to modify their own learning behavior.

This paper will focus on the ability of the learning disabled student to modify his or her performance on a given task through the process of reflective abstraction. Piaget (1976) defines this process as beginning with the pursuit of a goal or intention. The learner is therefore regarded as having a conscious awareness of the general nature of the response required in a task, and of success or failure in relation to it. Piaget argues that initially a task may be performed without a conscious awareness of all of the schemes or strategies used in its execution. In the case of failure, however, the learner begins to consciously analyze his or her behaviour. This analysis is characterized as starting with an examination of the stimulus characteristics of the response alternatives (and in some cases the characteristics of the stimuli used in the task) and leading to an attempt to examine the actions or strategies associated with the error. In re-examining the stimulus the learner may identify a feature which was not encoded in the first trial and which is in conflict with the scheme employed in the first trial. According to Piaget, this conflict may result in a modification of the scheme . Piaget (1976) provided evidence which suggests that within this paradigm the learner appears to allocate conscious attention to the newly identified stimulus feature and its relationship with previously identified stimulus features. On the other hand, there appears to be very little conscious awareness of the schemes being used and modified. However, if the modified or new scheme turns out to be successful and is then used repeatedly, the learner may develop a conscious awareness of it and may be able to verbalize this awareness in terms of processing products and response criteria. Piaget argues that this type of awareness reflects a conceptualization of the underlying scheme and results

in the transfer associated with 'operational' concepts.

Although Piaget has often been criticized for a failure to operationalize his definitions, this paradigm is surprisingly consistent with an information processing approach to learning. For example, Ericsson and Simon (1980) predict that subjects should not be able to give retrospective verbal reports on cognitive operations which are automatized. Operations such as the perceptual encoding of familiar features, holistic similarity matching, and certain types of semantic processing appear to occur automatically and without conscious awareness. Ericsson and Simon (1980) also argue that the intermediate operations in a given task, although processed in short-term memory, may be obliterated by ongoing processing demands leaving only their products in short-term store. In such cases subjects should be able to report on these products but not on the processes underlying them.

In a similar vein (Case, 1978) has developed a theory which specifies the short-term or working memory load of stimulus encoding and comparison strategies. Within the framework of Case's theory the complexity of a given strategy is in part, defined by the maximum amount of information that must be processed in short-term or working memory while applying it. Because of the capacity limitations of short-term store, Case argues that the subject retains only the products of operations needed for subsequent processing and normally does not attempt to perserve information from intermediate operations or information about underlying schemes. Case (1978) also predicts that the acquisition of new strategies or schemes will be in part, determined by the relationship between the amount of unused or available working memory capacity a subject has and the information processing demands of the strategy. For example, in

reflecting on an error, the learner may begin by re-examining the response alternatives and the stimuli of a problem and may identify a previously unnoticed feature. He or she may then attempt to use this new feature as a guide in constructing and testing a new strategy. Paying attention to this feature may not add to the working demand of the task if the subject choses to ignore the features that were processed on the first trial. Alternatively, the subject may have the working memory capacity requird to both pay attention to the new feature and coordinate this information with the feature information used in the previously employed strategy. However, if the requirement of coordinating this new piece of information with the information from the previous strategy results in overloading, Case's theory predicts that the learner will be unable to construct a new strategy.

Three additional points are worth noting. First, Case (1978) does not rule out the possibility that the new scheme (or the new component operation) may have to be retained in working memory and given conscious attention when it is first applied. Second, Case (1978) argues that a new scheme or strategy usually becomes automatized with repeated application and that this frees up working memory capacity for the acquisition of the next scheme. Third, Case sees working memory capacity as increasing between the ages of four and twelve as a function of the automatization of certain general executive strategies.

Within the framework of these theoretical arguments a number of predictions can be made in relation to the ability of a learner to modify his or her learning behaviour through the process of reflective abstraction. These are as follows:

(a) A subject should be able to modify his or her learning behaviour by constructing and testing a new strategy if the new strategy does not require paying attention to more information than can be retained in working memory.

(b) A subject should not be able to modify his or her learning behaviour by assembling and testing a new strategy (i) if the new strategy requires the coordination of more information than can be processed in working memory at one time and/or (ii) if the new strategy consists of operations which must be held in working memory while performing a task and as a result, cause overloading.

(c) Training designed to teach subjects to analyze the properties of the response alternatives and stimuli of a task after an error has been made should facilitate the construction and testing of new strategies and this should result in an improvement in performance, provided the new strategy does not overload working memory.

(d) Training designed to teach subjects verbal rules for a new strategy should improve performance on a task provided the new strategy or verbal rules do not overload working memory.

(e) Procedures designed to reduce the load on working memory produced by the need to remember the specific operations of a strategy should also facilitate performance, provided the strategy does not require the coordination of more information than can be coordinated in working memory at one time. However, procedures designed to reduce the load on working memory produced by the need to coordinate or integrate stimulus information may not improve performance (Brainerd, 1981) in that, although the experimenter can supply the subject with the requisite stimulus information, the coordinating cognitive operation must still be executed by the subject.

(f) Most important with respect to this paper, there is nothing in Piaget's (1976) or Case's (1978) theories which suggests that these predictions should be modified for the learning disabled subject. In other words, although children with learning disabilities might have less working memory capacity available than normal learners of the same age (Bauer, 1977), their ability to reflect on their learning behaviour should be no different than the normal learner when the task demands do not overload short-term store. Thus if learning disabled and normal subjects are matched on the basis of their working memory scores, one would expect similar changes in performance for both groups in relation to their ability to use the process of reflective abstraction to modify their learning behaviour.

In order to assess these predictions we have been carrying out a number of related experiments at the Reading Clinic of Brock University. In the first of these experiments we selected a task which met the criterion of requiring strategies which have been associated with specific working memory demands (Case, 1978; Wagner, 1981). The task was that of figural analogy problem solving. Previous research has suggested that this task may require the use of a bidimensional comparison strategy (Case, 1978) which is associated with a working memory demand of 3. For example, children with a measured working memory capacity of 2 appear to be unable to learn this task even when they demonstrate mastery of the prerequisite feature encoding, inferring, mapping operations (Wagner, 1981). Children with a working memory capacity of 3 or more on the other hand, given feedback,and shown the desired response, appear to be able to reach a criterion of 3 correct responses in a row on familiar figural analogy problems. Moreover, the shift in performance to an error rate of less than 15% which occurs when criterion is reached, is similar to the type of change in behaviour that is often observed with the acquisition of a concept rule or Piagetian operation. In addition, the errors made by children with a working memory capacity of 3 suggest that they must also learn to apply an exhaustive processing strategy (Sternberg, 1977; Sternberg and Rifkin, 1979) to figural analogy problems.

This latter observation suggests that children with a working memory capacity of 3 who are inclined to employ self-terminating processing strategies because of impulsivity,would benefit from training designed to teach them to analyze the properties of the response

alternatives and the stem terms of figural analogy problems. Alternatively, children with a working memory capacity of less than 3 who are inclined to exhibit impulsivity on tasks requiring analytic perception, might not benefit from this type of training.

In order to test this hypothesis two groups of children, classed as learning disabled by their school boards, were selected on the basis of their working memory capacity. Working memory capacity was assessed with two instruments developed by Case and Kurland (1976). These tests were administered individually and required the subject to retain information in short-term store while performing a nonautomatic operation in order to encode new information for storage. Subjects with a working memory score of 2 were placed in the first group which was designated as (L.D.-2) (Mean C.A. = 10.6, Range = 9.2 - 12.6, n= 12). Similarly, subjects with a working memory score of 3 were placed in the second group which was designated as (L.D.-3) (Mean C.A. = 11.29, Range = 8.6-12.5, n. = 12). Although WISC-R I.Q. data was not available nor up to date on all of these subjects, the scores that could be obtained indicated that the children in these groups were in the low normal range of 84-101. In addition, two groups of children without learning disabilities were used as controls. These children were from regular classrooms and classed as normal or average learners by their teachers. As was the case with the learning disabled children, subjects with a working memory score of 2 were placed in the first group (designated as L.N.-2) (Mean C.A. = 7.4, Range = 6.7 - 8.4, n = 12) and subjects with a working memory socre of 3 were placed in the second group (designated as L.N.-3)(Mean C.A. = 9.5, Range = 7.9 - 10.3, n = 12).

The treatment was a variation of the technique advocated by

Meichenbaum(1977) and was designed to facilitate the first step in Piaget's description of the process of reflective abstraction. Each subject was first pretested on 9 geometric figural analogy problems. Following this, in a separate session, each subject was asked to solve 9 people picture figural analogy problems. For each of these problems the child was asked to explain why the response alternative that had been selected was correct and why the remaining response alternatives were incorrect. The dependent variables were the number of subjects reaching and maintaining criterion and the number of trials to criterion. Criterion was set at 3 correct trials in a row plus performance above 50% correct after criterion had been reached.

— Insert Figures 1 and 2 about here. —

As can be seen from data in Figure 1, the subjects classed as learning disabled showed changes in performance similar to the subjects in the control groups. As predicted, a majority of the subjects in group L.D.-3 and L.N.-3 benefited from the training. On the other hand, the training did not appear to have much an effect on most of the subjects in groups L.D.-2 and L.N. -2.

Of equal interest is the data in Figure 2. Although there were individual differences in the number of trials to criterion in all of the groups, the subjects in L.D.-3 in general, appeared to require more time to reach criterion than the subjects in L.N.-3[(1)]. What is suggested is that although the subjects in L.D.-3 have the working memory capacity

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(1) This difference was not statistically significant.

required to assemble a bidimensional comparison strategy, their preference for self-terminating processing may lead to errors even when the bidimensional comparison strategy is correctly applied. For example, a child may carry out all of the operations of a figural analogy algorithm correctly but may fail to apply an exhaustive processing rule on a problem with more than one feature transformation between its stem terms (Sternberg and Rifkin, 1979). Unless the child perceives that one or two feature transformations were missed, however, he or she may infer that the bidimensional comparison strategy led to the error. Thus, the correct strategy may be discarded on the next trial. Confounding of this type may be more likely to occur with subjects who are prone to apply a self-terminating processing strategy before an exhaustive processing strategy and may increase the number of trials required to master a task.

Taken together, the data from Figures 1 and 2 support the argument that the learning disabled child will benefit from training designed to initiate the process of reflective abstraction by a (conscious) verbal analysis of the response alternatives and stimuli of a given task. This analysis may result in the recognition of stimulus features that were not processed during the problem solving attempt. The subject may then infer that a new strategy or processing rule is required on the next trial. If the new strategy does not require the coordination of more information than the subject can process in working memory, it will be tested on the next trial. If on the other hand the strategy has the potential to overload working memory capacity, the subject will be unable to use the new stimulus information to construct the strategy. This process appears to be the same in learning disabled and normal children although the learning disabled child may have to test more strategies than the normal

child and may have less working memory capacity available for such testing.

It is conceivable, however, that a subject may have the required working memory capacity for a new strategy but may not benefit from the conscious recognition of previously unrecognized response alternative and stimulus features because of the nature of the strategy. Although this did not appear to be the case with the figural analogy problems [1] there may be tasks in which the strategy that must be inferred requires a type of processing that is unfamiliar to the subject. In such cases, although the subject may have the working memory capacity required to integrate the previously unrecognized stimulus information in a new scheme, he or she may fail to infer the correct scheme. This type of difficulty, however, should be amenable to direct instruction on the required strategy, provided that the subject can retain the new strategy or processing rule in working memory while learning to apply it.

We have identified a task in our reading clinic which may present children with this type of learning problem. The task is a concept identification problem developed by the McGraw-Hill Book Company (1966, 1968) which is called the Creature Card Problem. In order to identify a concept on a Creature Card Problem the subject must be able to isolate a common feature in a set of 5 abstract stimulus configurations placed in a row and labelled "All of these are Wugs". Different pseudo names are used for each problem. Following this the subject must look at a second row of stimulus configurations labelled "None of these are Wugs," and make sure that the common feature abstracted from the first row is not

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(1) The bidimensional comparison strategy may require the coordination of 2 familiar schemes and may be new in this sense but it may not be new in the sense of requiring unfamiliar processing.

part of any of the stimuli. If the feature is found in the second row the subject must discard it and go back to the first row and begin again. If the feature is not on any of the stimuli in the second row the subject can infer that it is a criterial or defining feature and proceed to the third row of stimuli. The third row of stimulus configurations is entitled, "Which of these are Wugs?" and consists of positive and negative examples of the concept. The subject's task is of course,to identify new instances of "Wugs". The concepts are structured as simple concepts with 1 defining feature and as conjuctive concepts with 2 to 4 defining features.

We have administered this task to a group of 9 learning disabled children (Mean C.A. = 10.6, Range = 8.4 - 11.2) and 9 children from a regular Grade 4 classroom (Mean C.A. = 9.4, Range = 8.6 - 10.5). Each subject was tested individually on the three sets of problems. In the first set of problems the subjects were not given assistance apart from a general explanation of the task. In the second set of problems each subject was given a set of verbal processing rules before attempting a given problem. These rules were explained and presented orally. Finally, in the third set of problems the subjects were given a set of printed processing rules and required to read each one before executing the step it referred to in the problem algorithm. The subjects were given 6 simple concept and 6 conjunctive concept problems in each condition. In addition, each subject was asked to explain (a) how he or she knew what a "Wug" was and (b) what he or she did to figure out what a "Wug" was after each problem solving attempt.

The processing rules which were presented in the second and third conditions were as follows;

(1) Look at the first row.
Find something that is the same in all of the shapes (simple concept).
or: Find 2 (or 3) things thatare the same in all of the shapes (conjunctive concept).

(2) Look at the second row.
Make sure the thing you found in all of the shapes in the first row is not in this row (simple concept).
If you find it then that can't be what a "Wug" is. Go back to row one.
If you don't find it then that must be what "Wug" is. Go to the third row.
or: Make sure the 2 (or 3) things you found in all of the shapes in the first row are not together on any one shape in this row. (Conjunctive concept).
If you find a shape with these 2 (or 3) things then 1 or more of them must be wrong and that can't be what a "Wug" is. Go back to row one.
If you don't find a shape with these 2 (or 3) things together then that must be what a "Wug" is. Go to the third row..

(3) Look at the third row.
Look for shapes which have the thing you found in all of the shapes in row one. These are Wugs. (Simple concept).
or: Look for shapes which have the 2 (or 3) things you found in all of the shapes in the first row. These are Wugs. (Conjunctive concept).

The reader will have noted, of course, that the three conditions in this study were not strictly independent. It is possible for example, that the probes administered after each trial may have facilitated the acquisition of specific processing strategies in the second and third conditions. Similarly, the oral presentation of the strategy in the second condition may have facilitated performance in the third condition. Therefore, although there was a one week interval between the administration of each condition, this experiment probably should be regarded as a clinical study designed to explore the factors associated with strategy learning in a concept identification task.

— Insert Figure 3 and 4 about here. —

The results were quite interesting. To begin, the verbal protocols of both the L.D. children and the normal grade four children indicated that many of the subjects employed a matching strategy in the first condition. For example, the selection of a response alternative in the third row was justified with references to both criterial and noncriterial features which matched a stimulus in the first row. As expected, references to strategies were often incomplete. However, these references also indicated that a matching strategy was being used. "I looked here (top row) and then at these ones(bottom row)" was a frequent response. When combined with the error data these responses suggested that several of the subjects in both groups were not abstracting a common feature from the first row and were not looking at the second row. In addition, the verbal protocols suggested that these subjects were capable of recalling their response criteria and strategies but that this reflection did not result in the retrieval or development of a new strategy.

As can be seen in Figure 3, the oral presentation of the processing rules had less of an effect on performance than the printed presentation. This is what one would expect, however, if the processing rules represented a new strategy which had to be held in working memory while being employed. Having the subject read each processing rule before attempting to comply with it and allowing the subject to refer back to the printed rule when he or she needed to,on the other hand,resulted in large shifts in performance. Again, this is what one would expect if the subject was experiencing difficulty in remembering a processing rule or strategy itself. Three additional observations are worth noting. First, when a subject's performance improved with the

presentation of the processing rules in the printed format there was corresponding change in the response criteria reported after each trial. In general, the verbal protocols appeared to reflect the acquisition of the new processing rule. Second, as is indicated in Figure 4, the presentation of the conjunctive concept processing rules in the printed format was not as facilitating as the presentation of the simple concept processing rules. Inspection of the response data and the verbal protocols associated with the simple concept items and the conjunctive concept items suggested two potential explanations of this observation. The data indicated that subjects made an increasing number of errors on the 2 and 3 feature conjunctive concepts because of a failure to apply an exhaustive processing strategy when identifying the common features in row one of the task. Although this type of error was made by the subjects in both groups, more of these errors were made by the subjects in the L.D. group. There was also some evidence, however, which suggested that 3 of the younger subjects were reading the conjunctive concept rule but not applying the strategy of looking for shapes in the middle row with 2 (or 3) of the common features abstracted from the first row. In other words, reading the processing rule used to represent this strategy was not sufficient for these children. As the third, and final point, it should be noted that for the simple concept items, the change in performance associated with the printed processing rule condition was similar for both the learning disable and the normal subjects.

In summation, it can be argued that the results of these studies, although preliminary, point to two major conclusions. First, the process of reflective abstraction appears to be a process that is available and used by both the normal and the learning disabled child. Second, the

deployment of strategies brought to bear through the process of reflective abstraction may be limited by the demand the strategy places on working memory and the type of processing required by the strategy. For this reason, new or unfamiliar strategies which require conscious attention while being applied and strategies which have a high information integration component may require a more sustained type of intervention then has been associated with low demand strategies such as the exhaustive processing strategy (Kagan, 1966; Michenbaum, 1977). It may be necessary for example, to ensure that both the component operations and the processing rules of the former type of strategy can be applied automatically if transfer and an operational conceptualization (Piaget, 1976) of the strategy is to be expected. Finally, it is important to note that the learner and more probably the disabled learner, may fail to apply a low demand strategy such as exhaustive processing, when testing a new strategy such as the bidimensional comparison strategy. Errors resulting from the failure to use an exhaustive processing may result in a discarding of the correctly applied bidimensional comparison strategy. Thus interference from a low demand strategy may retard the acquisition of higher order strategies. Moreover, the probability of this occurring may increase with the complexity of a given task.

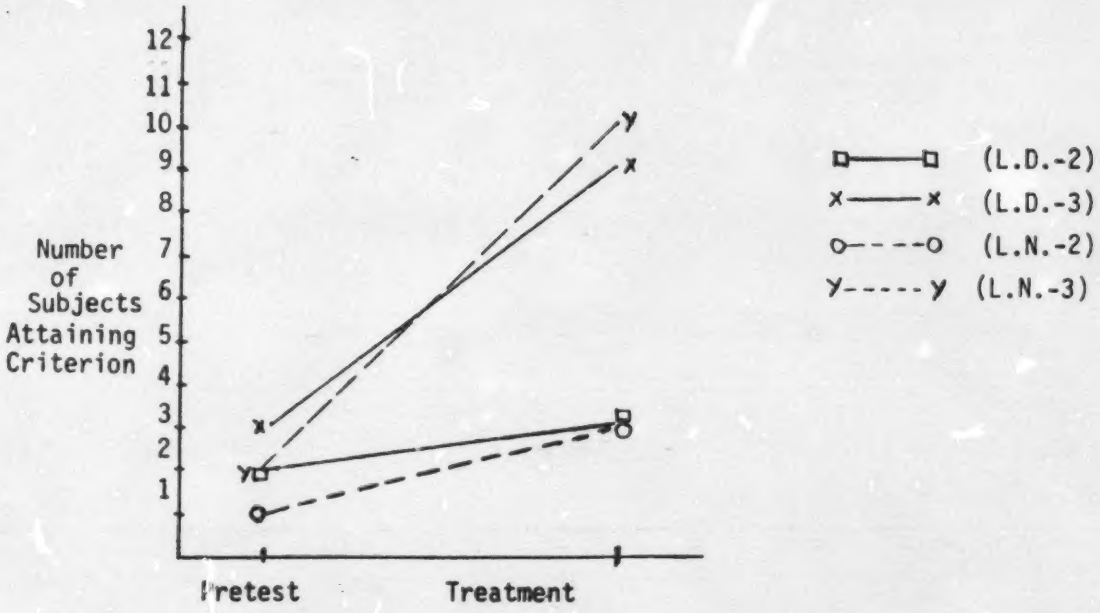


Figure 1

Number of Subjects in Each Group Reaching & Maintaining Criteria

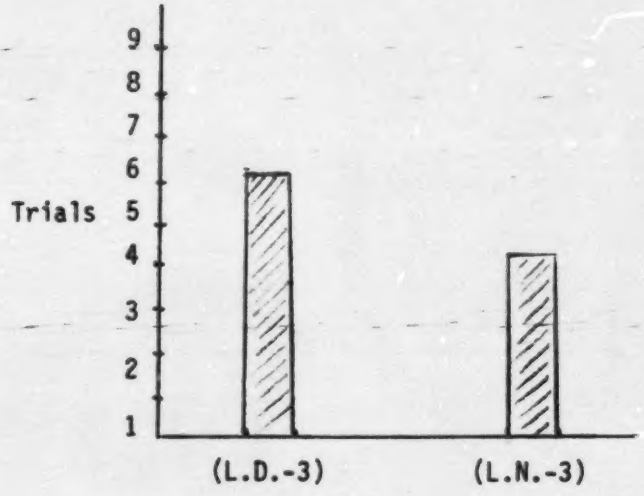


Figure 2

Mean Number of Trials to Criterion

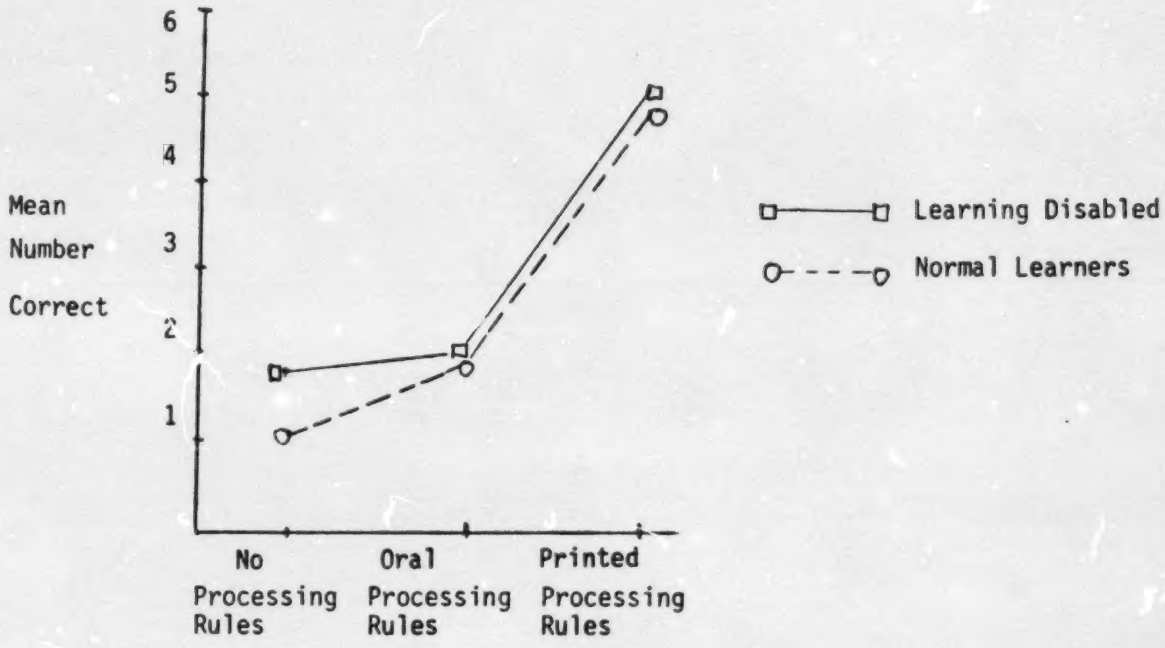


Figure 3

Simple Concept Group Means

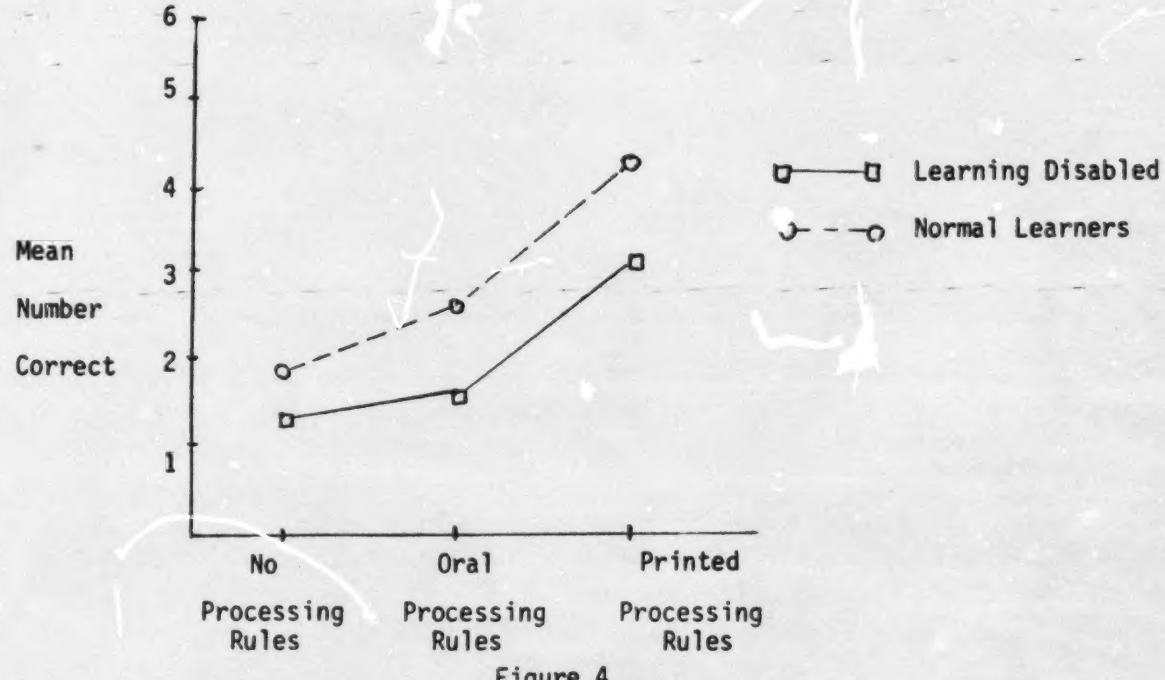
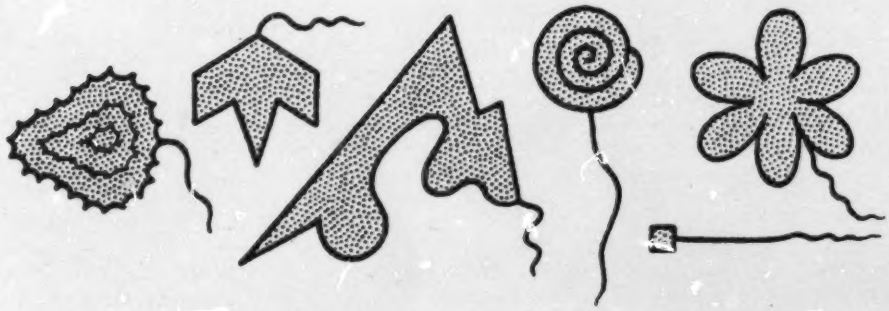


Figure 4

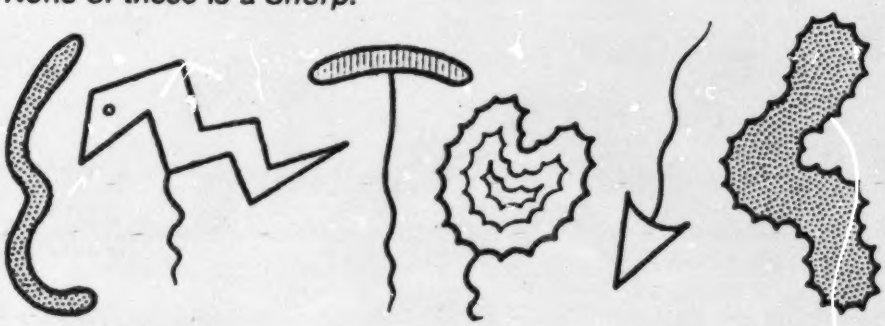
Conjunctive Concept Group Means

Creature Card 7 *Snorps*

All of these are *Snorps*.



None of these is a *Snorp*.



Which of these are *Snorps*?

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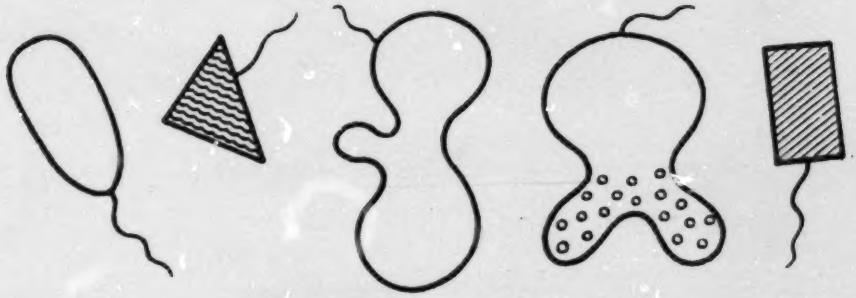
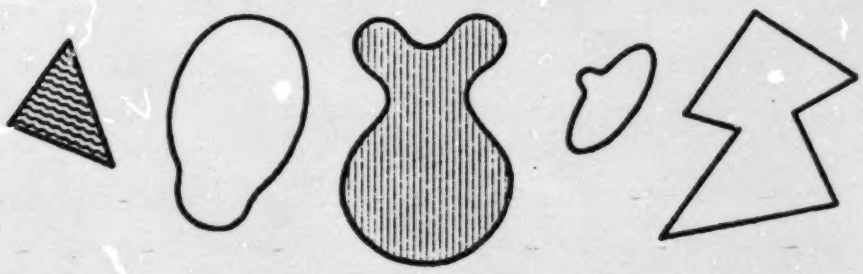
Creature Card 3 *Wibbles*

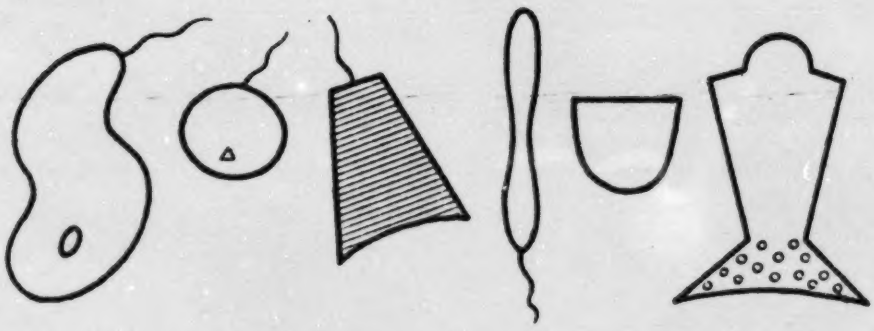
All of these are *Wibbles.*



None of these is a *Wibble.*



Which of these are *Wibbles?*



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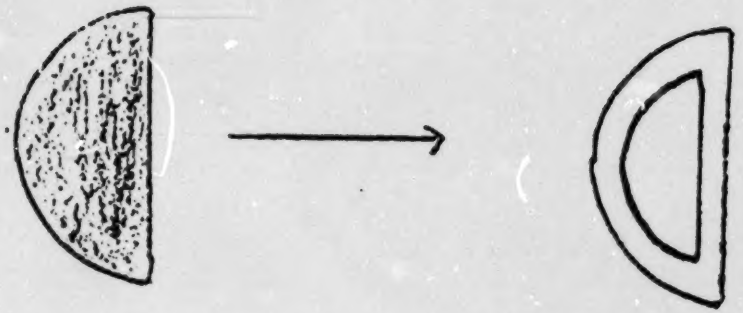
GEOMETRIC FIGURAL ANALOGY PROBLEM



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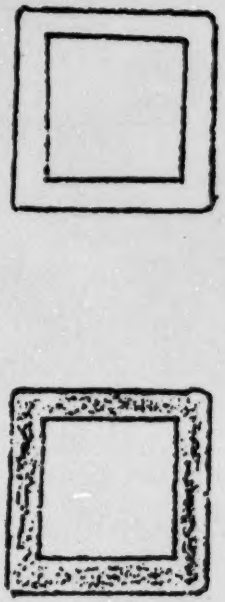

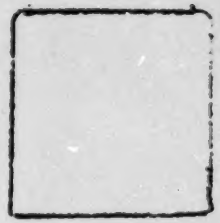

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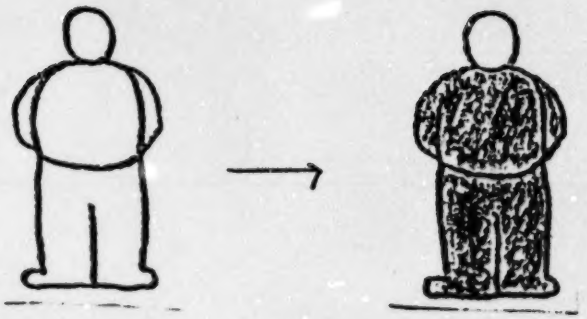
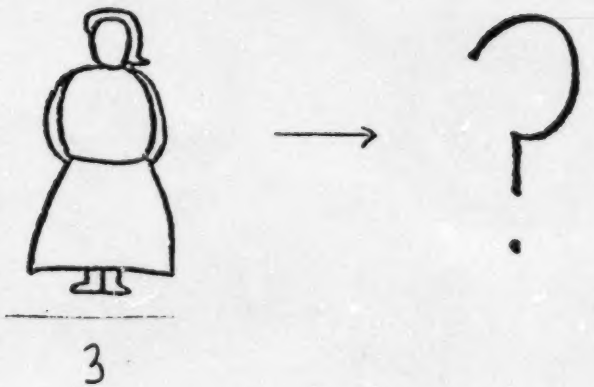
PEOPLE PICTURE FIGURAL ANALOGY PROBLEM





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